



# Mars Exploration Program (MEP) Program Update

Presented to:

**Planetary Science Subcommittee**

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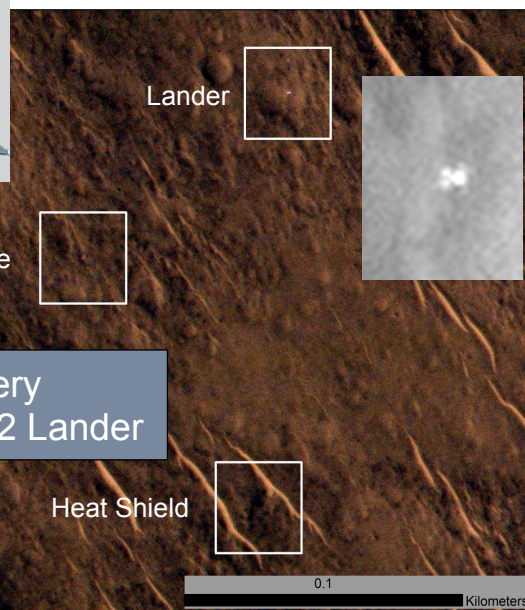
March 30, 2015



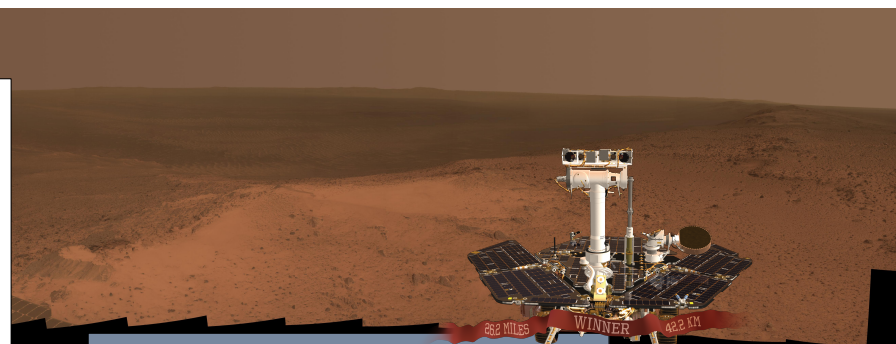
# MEP Highlights at Mars



MAVEN probing Martian atmosphere



MRO HiRISE Imagery locates the Beagle-2 Lander



OPPORTUNITY  
a record run! 42.195 km  
(time 11 yrs 2 months)



CURIOSITY exploring Gale Crater



# Mars Exploration Program Status - Summary

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## Overall, the state-of-the-MEP is good

- Our operational assets remain healthy and productive:
  - MAVEN having productive primary mission
  - Odyssey continues to provide thermal imagery and data relay services while drifting to a new orbit to diversify observations
  - MRO continues to provide reconnaissance imaging for surface operations, conduct landing site surveys for the Mars 2020 and ExoMars rovers, and provide mineralogical data
  - Opportunity rover continues to produce valuable ground truth data to validate orbital remote sensing
  - Curiosity is now intensely exploring the base of Mt Sharp in Gale Crater. Percussive drill operations temporarily suspended while intermittent short anomaly being investigated
- Two significant development activities are underway:
  - Mars 2020 has passed SRR/MDR and is proceeding to KDP-B
  - MOMA-MS, a NASA partnered contribution for the 2018 ExoMars Lander, is in flight fabrication and assembly
- We are meeting our international commitments:
  - Continuing to operating our collaborative deep radar sounder (MARSIS) on Mars Express
  - Delivered & integrated 2 Electra payloads to the ESA Trace Gas Orbiter
    - Continue to work towards a 2016 launch
  - ISRO has joined us in Mars orbit. We are looking forward to building a stronger relationship as they consider returning to Mars with a subsequent mission.
    - MAVEN now collaborating with their MOM mission.
- Financially, the program is doing better, but continued attention is needed for the future:
  - In FY15, having received slightly more from Congress than requested, all our planned activities will be funded
  - In FY16, the President's budget again supports MEP well, allowing us to keep Mars 2020 on track

# Mars Exploration Program Science

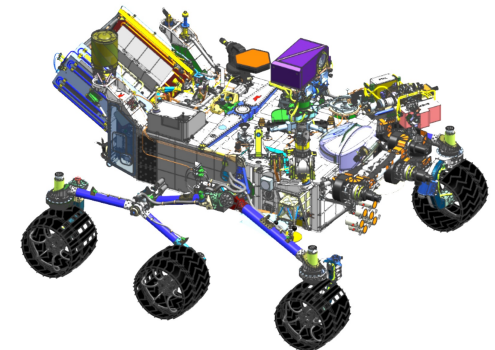
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- **Science Increasing Understanding of the Martian System**
  - Comet Siding Spring observations
    - MAVEN measured metallic signatures of comet dust in upper atmosphere
    - Mars Express/MARSIS observed transient comet-induced ionosphere ~100km
  - MAVEN observations revealed new phenomena
    - High-altitude day side dust cloud near terminator
    - Broadly distributed diffuse low altitude aurora reaching deep into the Martian atmosphere
    - Atmospheric energy exchange with solar wind
  - MRO & Mars Express observations expanding understanding of CO<sub>2</sub> in Martian environment
    - Greater presence of subsurface ice
    - High altitude CO<sub>2</sub> ice clouds
  - CURIOUSITY traversed to the slopes of Mt. Sharp and is continuing ongoing analytical measurements
    - Curiosity measured variations in methane abundance on the traverse to Mt. Sharp
    - Now exploring a hypothesis that tilted sediment beds on Gale Crater's plains indicate fluvial transport of sediment toward Mount Sharp, building up from ancient streams & lakes
    - SAM instrument made the first detection of Martian organics and nitrates
  - OPPORTUNITY examining rock diversity on Cape Tribulation overlooking Marathon Valley
- **Progress being made on Landing Site Observations**
  - MRO has satisfied ~50% of all current landing site characterization requests for InSight, ExoMars, & Mars 2020 missions
  - Mars 2020 2<sup>nd</sup> Landing Site Workshop - Summer 2015



# Mars 2020 Update – Phase A Progress

- ❑ Completed the System Requirements Review / Mission Definition Review milestone that marks the end of Phase A
  - Completed instrument accommodation reviews, including implementing design modifications required at selection
  - SRB reported: *“Project is more mature than most in Phase A, ready for KDP-B decision milestone and Phase B start.”*
- ❑ Working detailed engineering and design trades for cache system implementation
- ❑ Heritage hardware (~80-90% of the flight system by mass) is essentially in Phase C/D. Parts buys and procurements for items with low risk of change are proceeding at a fast pace
  - 99% of electronic parts have been ordered allowing early build of heritage flight boards
  - 36 flight boards delivered and in test; 23 flight boards in final assembly; many others in manufacturing queue
- ❑ Dropped trade study for augmented direct-to-Earth communication since MRO, MAVEN, and ESA Trace Gas Orbiter are on track to provide relay
- ❑ Published environmental impact statement and issued Record of Decision to baseline radioisotope power system, thus completing compliance with National Environmental Policy Act (NEPA)
- ❑ Upgraded engineering camera design with color and higher resolution than MSL navcam/hazcams
- ❑ Continue to evaluate Terrain Relative Navigation (TRN) capability for potential inclusion on the mission

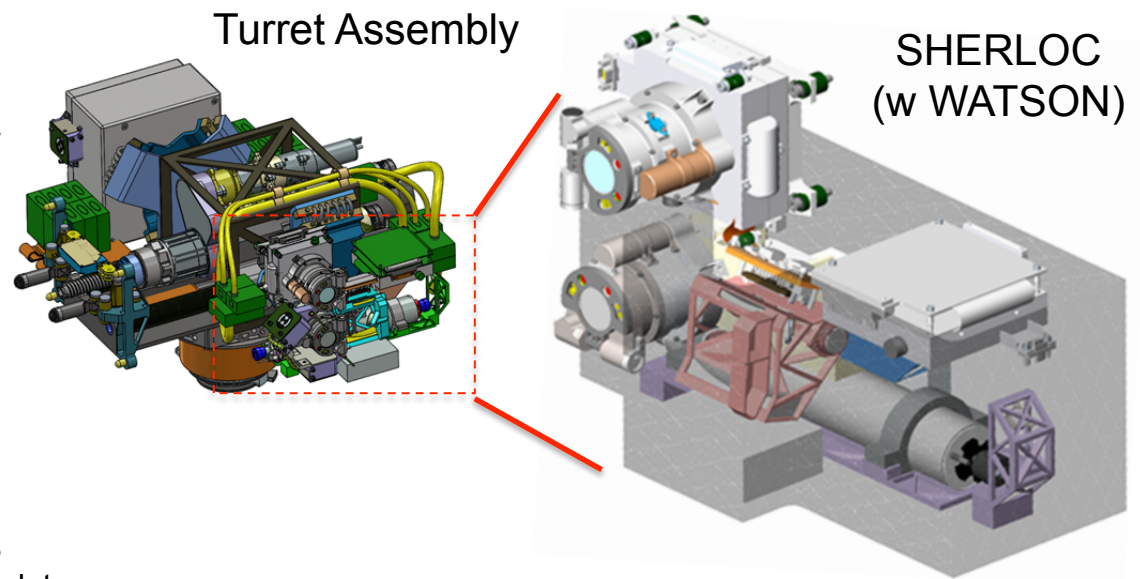


**Project has made excellent progress to date, but plenty of challenging work still ahead**

# Mars 2020 Payload Update

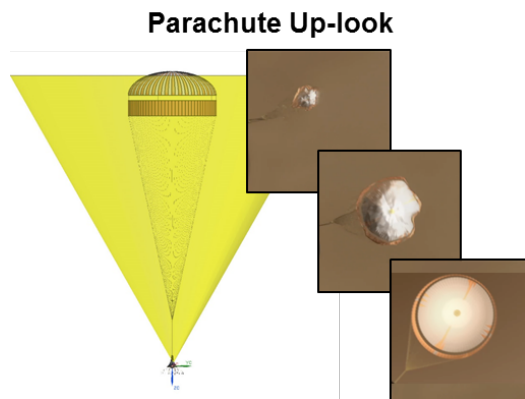
## Added Wide Angle Topographic Sensor for Operations and eNginEering (WATSON)

- Augmented turret fine-scale imaging capability by adding MAHLI heritage optic + mux board to SHERLOC instrument
- Provides contextual science and engineering data

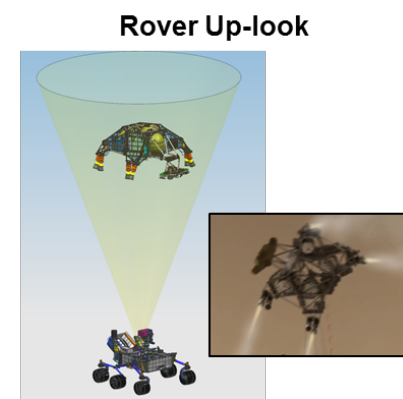
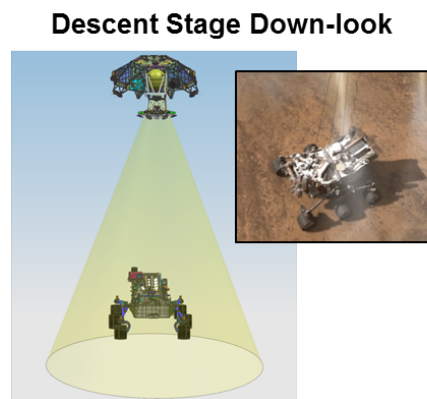


## Added EDL / Parachute Uplook Cameras

- Improved EDL instrumentation for engineering data
- Parachute up-look, descent stage down-look, & rover up-look cameras



3/30/15





# MOMA-MS Development

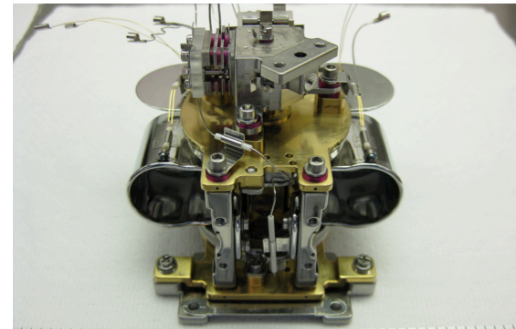
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- **MOMA-MS Progress**

- CDR completed – September 2014
- Flight Model (FM) H/W build underway

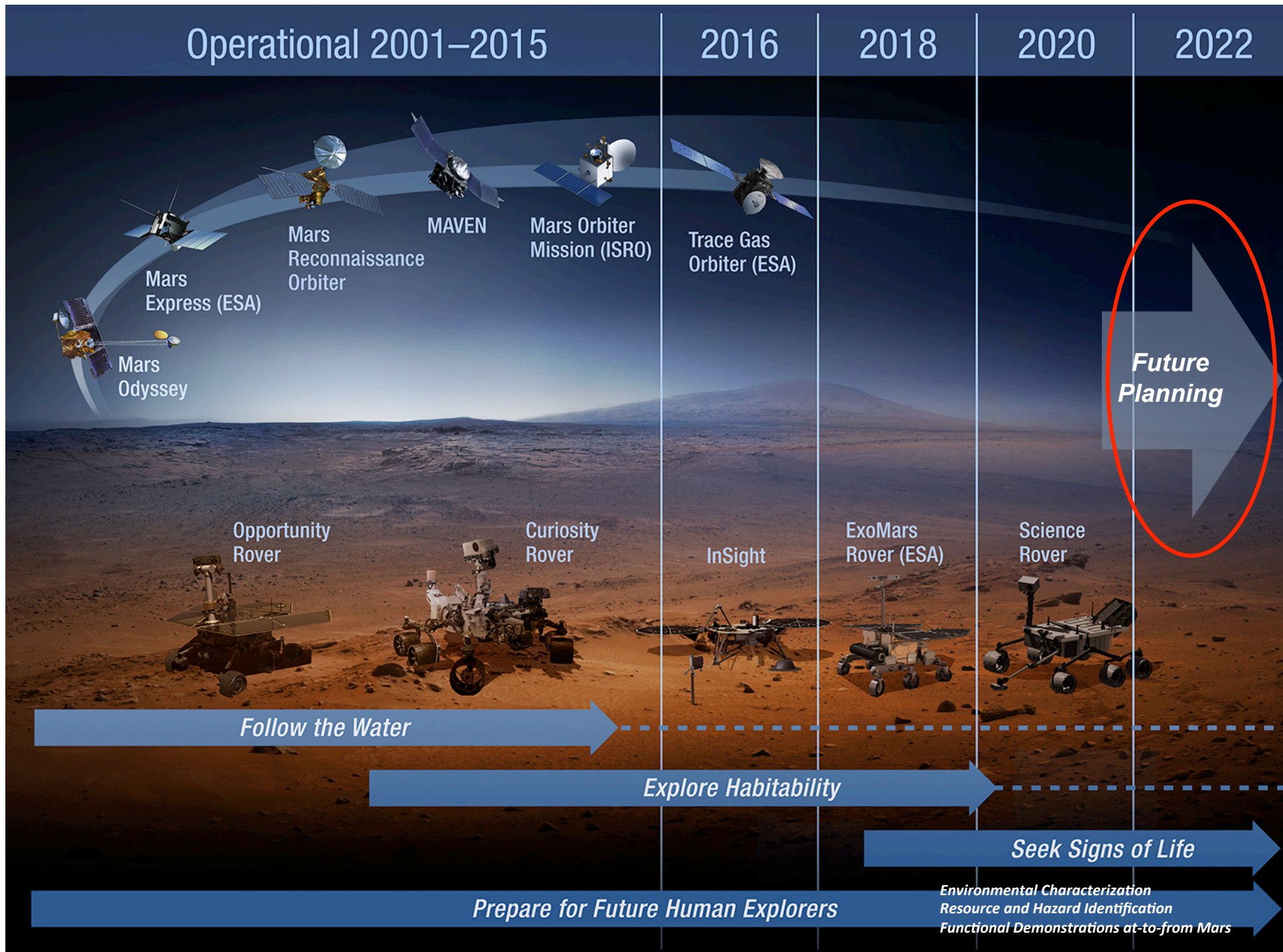
- **ExoMars 2018 Mission Progress**

- Mission PDR Completed – October 2014
- System PDR to be completed – May 2015



- **Challenges**

- CNES delivery of MOMA-GC electronics and DLR flight laser significantly delayed due to lack of funding. ESA evaluating impact of delayed delivery on launch schedule vs reduced science if flown without CNES contributions
  - DLR FM laser >10 month delay
  - MOMA-GC FM electronics >17month delay
- MOMA-MS FM delivery to MPS on schedule
  - All schedule reserves utilized
  - Delivery date achievable only if international partner elements can recover lost schedule

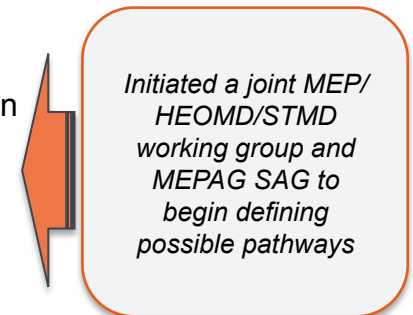




# MEP Future Vision

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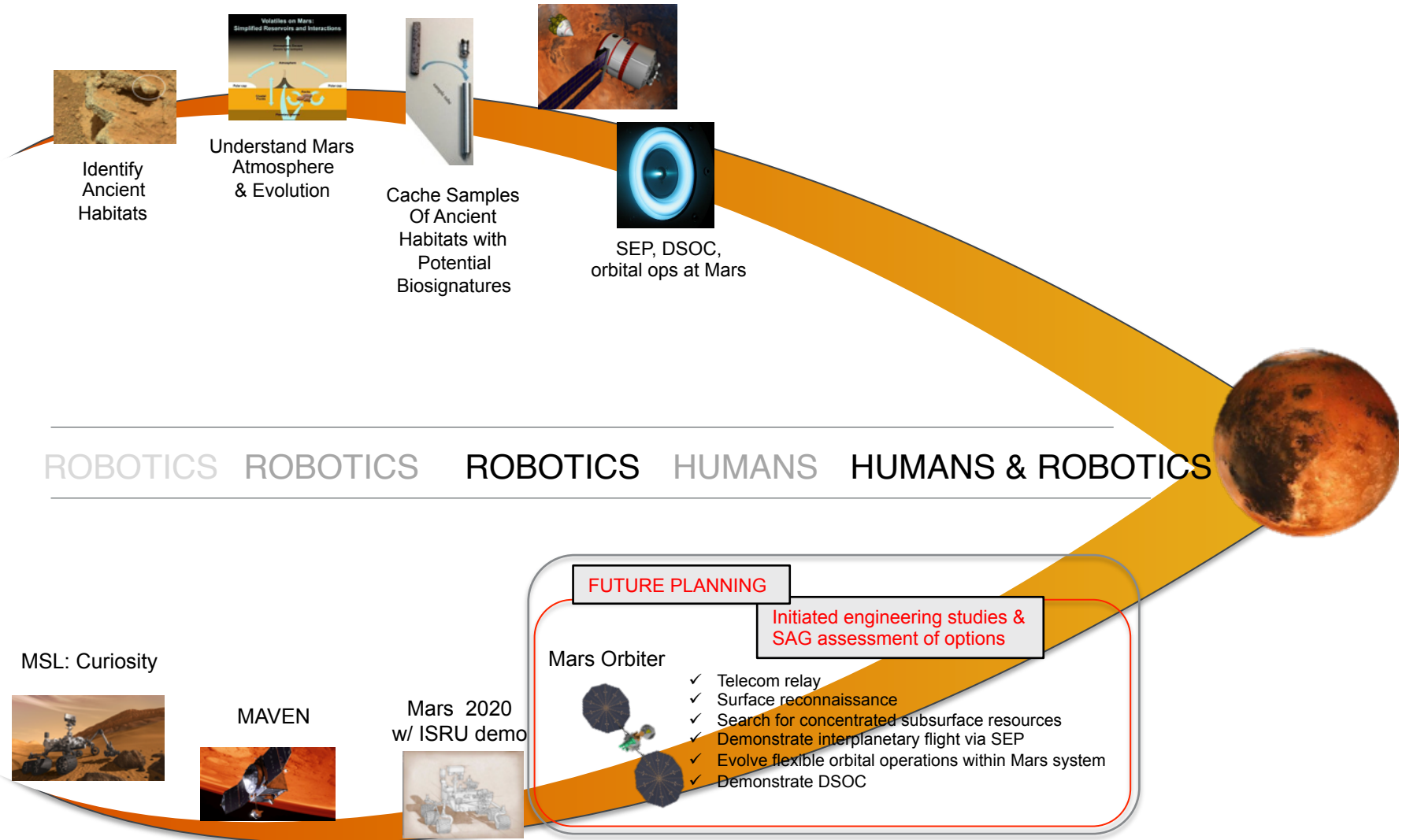
- ❑ **Guiding Themes:** Serve exploration stakeholders through synergistic partnerships:
  - ✓ **Science:** Conduct highest priority science building on Decadal Survey priorities
    - Address keystone scientific questions about planetary habitability and the possibility of life beyond Earth
    - Be agile and robust, able to respond to discovery
  - ✓ **Inform and enable Human Mission design:** Provide knowledge, experience and technology to retire crew safety and operability risks, mature end-to-end systems engineering and continue building operational experience
    - Address key issues to build confidence in round-trip missions to/from Mars
    - Identify and characterize concentrated resources for potential ISRU exploitation
    - Respond to emerging needs
  - ✓ **Infrastructure:** Sustain and improve Mars telecommunications and surface reconnaissance infrastructure
  - ✓ **Technologies:** Capitalize on and validate advanced technical capabilities that inform conceptual designs for future human missions and enable end-to-end Earth/Mars missions with robotic precursors
- ❑ **Implementing Principles:** Timely and responsive approaches that provide affordable solutions:
  - ✓ Incremental steps composed of *Strategic* and *Competed* elements
  - ✓ Leverage and support *integrated partnerships*



The 2020's would be a “**transition decade**” that sustains and increases Mars exploration capabilities by embracing new partnerships to leverage and amplify the science driven program elements in a manner that both advances science and promotes technology to help enable broader exploration initiatives across the Agency

# *Notional* Evolution of the MEP

MISSIONS CAPABILITIES



**Exploration Partnership Creates the Potential to Affordably Advance Capability**



# Summary

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## ☐ **MEP is healthy and improving**

- ☐ Operational assets returning remarkable science
- ☐ Budget headed towards healthy level
- ☐ Mars 2020 development proceeding well

## ☐ **NRC Decadal Survey science priorities are guiding future planning**

- ☐ Exploring Science/Exploration synergies to produce significant, affordable capability for both
- ☐ Science guided pathways provide natural precursor capability for Exploration needs

## ☐ **The time to begin planning for a MEP future is now (FY17 Budget cycle)**

## ☐ **An Orbiter appears to be the next logical step**

- ☐ Begun studies and assessment of options to identify a possible path forward
- ☐ Examining synergies with HEOMD and STMD that might improve mission productivity

**A partnered MEP would be an effective catalyst for focusing the early stages of NASA's *Journey to Mars***